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THE RELATIVE EFFECT OF A TIME  
INTERVAL UPON LEARNING  
AND RETENTION

A DISSERTATION SUBMITTED TO THE  
FACULTY OF THE DIVISION OF THE  
BIOLOGICAL SCIENCES IN CANDIDACY FOR  
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF PSYCHOLOGY

1938

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LILLIAN M. JOHNSON

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## THE RELATIVE EFFECT OF A TIME INTERVAL UPON LEARNING AND RETENTION<sup>1</sup>

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### INTRODUCTION

Many experiments have demonstrated the efficacy of distributed practice, that is, that the introduction of a time interval between trials facilitates learning. On the other hand, numerous experiments have demonstrated that forgetting occurs with the passage of time. Thus, a time interval has been shown to be detrimental to retention and beneficial in respect to learning. The results of these two sets of experiments seem to be contradictory, for if forgetting occurs during the interval, the paradoxical conclusion follows that forgetting is an aid to learning.

However, forgetting does not always occur with the passage of time. Under some conditions retention improves during short intervals. Such results have been reported as the phenomenon of 'reminiscence' by Ballard (2), Huguenin (9), Nicolai (16), Brown (3), Williams (25), G. O. McGeoch (13, 14), and others. Although not all of its determining conditions are known, the fact of reminiscence has been well established.

Neither does an interval always exert a facilitative effect upon learning. Under certain conditions the introduction of a time interval between trials may be detrimental. The character of its effect is probably a function of several factors.

The length of the interval seems to be one determining condition. The insertion of extremely long intervals in the course of learning would hardly be expected to be economical. However, most of the experiments have been concerned with

<sup>1</sup> From the Psychological Laboratory of the University of Chicago.

The writer wishes to acknowledge her indebtedness to Professor Harvey A. Carr under whose direction this study was made.

the length of the 'optimal interval' and hence no very long intervals have been employed.

The number of times an interval is introduced during learning may also affect its efficacy. In most experiments the interval has been inserted frequently during learning, that is, after each trial or after each two or three trials. Such a frequent and repetitive introduction of the interval has operated to facilitate the rate of learning. In one study, that of McClatchy (12), the interval was inserted but once during learning. When a forty-eight hour interval was introduced at various stages in the learning process, it was found to be detrimental in five positions and beneficial in only one. A twenty-four hour interval also produced a detrimental effect at one point of interpolation.

Furthermore, the effect of the interval during learning has been shown to vary with the criterion used to determine its efficacy. Some experiments (1, 7, 11, 20, 22) have shown it to be ineffective or even detrimental to immediate recall (or speed of learning), as compared with a control condition without an interval, but superior in terms of delayed tests of retention. Obviously such results do not indicate an increased speed of learning due to the interval.

Finally, the advantages of distributed practice have sometimes merely been assumed. Some investigations (4, 5, 6, 8, 10, 15, 17, 19, 23, 24) have been undertaken to show *which* of several forms of distribution (or insertion of intervals in learning) was *most* economical without the inclusion of a control condition with no interval. In such studies the comparisons have been between various forms of distributed practice (or schemes of insertion of time intervals in learning). It may be noted that in some of these the most advantageous conditions have been those with the most massing of practice, that is, with fewer or shorter intervals (18, 21).

Although much work has been done on the effect of a time interval upon retention and upon learning, the two problems have been studied in separate experiments and hence under different experimental conditions. One differential condition



has been pointed out, that is, that the interval is usually inserted a number of times in learning experiments; whereas, only a single interval is employed in the study of retention. Inasmuch as it has been shown that an interval can exert either a beneficial or detrimental effect upon either learning or retention, it is possible that the interval may produce the same effect upon the two processes when *both* are studied under the *same* experimental conditions. Our experiment was designed to test this hypothesis.

### PROBLEM

The purpose of this investigation was to study the relative influence of a time interval upon learning and upon retention in the same experimental situation and hence under identical conditions.

### PROCEDURE

The materials used consisted of five lists of twenty-one three-letter nouns which were learned by the anticipation method with oral recall. The words were presented serially by an electrically driven drum timed for a two-second exposure for each word and a ten-second interval between successive trials. The first word in each list served as a cue for anticipation so that only twenty words were recalled. The number correctly anticipated on each trial was recorded by the experimenter, and the lists were learned to the criterion of one perfect recitation.

There were two experiments differing only in the length of the interval used. In both, the interval was inserted only once during learning. The five conditions in each experiment differed according to the stage of learning at which the interval was inserted. In Condition A the interval was introduced after the subject had recalled as many as three words on one trial. In Condition B the insertion was made after each subject had recalled at least seven words; and in Conditions C and D it was inserted after the trial on which a minimum of eleven and fifteen words, respectively, was correctly recalled. Thus, for the group as a whole, the interval was inserted after an average recall of approximately four, eight, twelve, and sixteen words. In Condition E no interval was introduced until the subject had attained the criterion set for learning, that is, one correct repetition of all twenty words.

Thirty subjects, university students, were employed in each experiment, and they were divided into five sub-groups of six subjects each according to the order in which they took the several conditions. The order of procedure is represented in Fig. 1. The five conditions are indicated by the letters A, B, C, D, and E. The sub-groups are denoted by the Roman numerals I-V, and the lists are numbered from 1 to 5 in the order in which they were learned. According to this procedure, each condition was taken an equal number of times in each position in the sequence, and each list was learned an equal number of times in each condition.

|     | I | 2 | 3 | 4 | 5 |
|-----|---|---|---|---|---|
| I   | A | B | C | D | E |
| II  | B | C | D | E | A |
| III | C | D | E | A | B |
| IV  | D | E | A | B | C |
| V   | E | A | B | C | D |

FIG. 1. Order of procedure.

Since the group results for each of the five conditions are based upon the data for all subjects in each experiment and for all five lists, the differences in group results are attributable to differences in conditions (A, B, C, D, E) rather than to differences in subjects or lists of words.

The influence of practice upon the comparative data for the five conditions was minimized in three ways: (1) All subjects learned a practice list under the regular conditions of the experiment before starting on the experimental cycle; (2) only one list was learned each week; (3) the practice effect was equated by varying the order of the five conditions in a counterbalanced fashion for the five sub-groups (as illustrated above).

The effects of two intervals was studied—one day and three days. The same lists were employed in both experiments, but of necessity two different groups of subjects were used. Each subject learned at approximately the same hour of the day and on the same days of the week throughout the experimental cycle.

## RESULTS

*The Effect of the Interval upon Learning.*—The effect upon learning was measured by comparing the average number of trials required in each of the five conditions to learn the lists to the criterion of one perfect repetition. In Conditions A, B, C, and D the interval was inserted at different stages of learning. In Condition E no interval was employed before the criterion trial. The numerical data for each of the five conditions and for the two lengths of intervals are given in Tables 1 and 2. The mean numbers of trials to learn, the standard deviations, and standard errors of the means are given in Table 1. The differences between the number of trials to learn in Condition E and the conditions with an interval, the standard errors of the differences, and the critical ratios are presented in Table 2.

Inspection of these tables indicates that both intervals exerted a detrimental effect upon learning at all four stages at which they were introduced. On the basis of the critical ratios the detrimental effect can be considered statistically significant in five of the eight conditions. The consistency of the detrimental effect is further attested by its presence in



TABLE 1  
MEAN NUMBER OF TRIALS TO LEARN

| Condition | One-Day Interval |      |            | Three-Day Interval |      |            |
|-----------|------------------|------|------------|--------------------|------|------------|
|           | Mean             | S.D. | $\sigma_m$ | Mean               | S.D. | $\sigma_m$ |
| A         | 15.80            | 5.00 | .91        | 18.00              | 7.53 | 1.37       |
| B         | 17.30            | 5.17 | .94        | 18.53              | 7.11 | 1.30       |
| C         | 17.33            | 5.08 | .93        | 20.27              | 6.91 | 1.26       |
| D         | 18.57            | 5.12 | .93        | 19.33              | 7.18 | 1.31       |
| E         | 15.23            | 4.12 | .75        | 15.53              | 6.45 | 1.18       |

TABLE 2  
DIFFERENCES IN MEAN NUMBER OF TRIALS TO LEARN WITH AND WITHOUT INTERVAL

| Conditions | One-Day Interval |               |      | Three-Day Interval |               |      |
|------------|------------------|---------------|------|--------------------|---------------|------|
|            | Dif.             | $\sigma$ dif. | C.R. | Dif.               | $\sigma$ dif. | C.R. |
| A-E.....   | .57              | .54           | 1.06 | 2.47               | 1.08          | 2.28 |
| B-E.....   | 2.07             | .67           | 3.08 | 3.00               | 1.07          | 2.81 |
| C-E.....   | 2.10             | .63           | 3.34 | 4.74               | .84           | 5.64 |
| D-E.....   | 3.34             | .65           | 5.15 | 3.80               | .95           | 4.02 |

all eight cases. These results are more decisive in this respect than those of McClatchy. They suggest again that the detrimental or beneficial effect of an interval is a function of the number of times it is introduced during learning.

A greater detrimental effect was obtained for the longer interval in all four comparisons of the corresponding conditions.

For both intervals, the detrimental effect increased the later the interval was introduced with but one exception. In the case of the three-day interval the greatest number of trials was required to learn in Condition C.

*The Effect of the Interval upon Retention.*—Since the effect of the interval upon retention was found to be detrimental in this experiment, measures of amount of loss were calculated rather than measures of amount retained as is usually done. The loss in retention was measured in terms of: (1) the difference between the number of words recalled before and after the interval, (2) the percentage relation of this difference to the number of words recalled before the interval, (3) the number of trials required to relearn to the criterion attained

before the interval, and (4) the percentage relation of these relearning trials to the number of learning trials before the interval. The numerical data are given in Tables 3, 4, 5, and 6.

Table 3 lists the average number of words correctly recalled before and after the interval for each of the conditions

TABLE 3  
MEAN NUMBER OF WORDS CORRECTLY RECALLED \*

| Condition | One-Day Interval |           | Three-Day Interval |          |
|-----------|------------------|-----------|--------------------|----------|
|           | Before           | After     | Before             | After    |
| A         | 4.93±.26         | 1.30±.27  | 4.60±.26           | .97±.19  |
| B         | 8.27±.18         | 2.33±.38  | 7.90±.21           | 1.57±.36 |
| C         | 12.10±.21        | 4.57±.51  | 12.50±.20          | 2.67±.49 |
| D         | 15.87±.14        | 6.20±.45  | 16.17±.20          | 3.93±.76 |
| E         | 20.00            | 10.93±.74 | 20.00              | 6.03±.73 |

\* The measures of variability are standard errors.

TABLE 4  
LOSS IN RECALL AFTER THE INTERVAL

| Condition | Mean Number of Words Lost |                    | Percent of Words Lost |                    |
|-----------|---------------------------|--------------------|-----------------------|--------------------|
|           | One-Day Interval          | Three-Day Interval | One-Day Interval      | Three-Day Interval |
| A         | 3.63                      | 3.63               | 73.63                 | 78.91              |
| B         | 5.94                      | 6.33               | 71.83                 | 80.13              |
| C         | 7.53                      | 9.83               | 62.23                 | 78.64              |
| D         | 9.67                      | 12.24              | 60.93                 | 75.70              |
| E         | 9.07                      | 13.97              | 45.35                 | 69.85              |

TABLE 5  
MEAN NUMBER OF TRIALS TO LEARN BEFORE INTERVAL AND TO RELEARN AFTER INTERVAL \*

| Condition | One-Day Interval |           | Three-Day Interval |           |
|-----------|------------------|-----------|--------------------|-----------|
|           | L. Trs.          | Rel. Trs. | L. Trs.            | Rel. Trs. |
| A         | 2.47±.13         | 2.33±.09  | 2.40±.49           | 2.27±.11  |
| B         | 4.23±.35         | 2.77±.19  | 4.27±.53           | 2.93±.17  |
| C         | 6.07±.39         | 3.57±.25  | 6.53±.42           | 5.27±.43  |
| D         | 8.77±.52         | 4.93±.37  | 9.17±.64           | 5.77±.53  |
| E         | 15.23±.75        | 5.57±.40  | 15.53±1.18         | 7.10±.64  |

\* The measures of variability are standard errors.



TABLE 6  
PERCENTAGE RELATION BETWEEN RELEARNING AND LEARNING TRIALS

| Condition | Relearning Trs.<br>Learning Trs.<br>One-Day Interval | Relearning Trs.<br>Learning Trs.<br>Three-Day Interval |
|-----------|------------------------------------------------------|--------------------------------------------------------|
|           |                                                      |                                                        |
| A.....    | 94.33                                                | 94.58                                                  |
| B.....    | 65.48                                                | 68.62                                                  |
| C.....    | 58.81                                                | 80.70                                                  |
| D.....    | 56.21                                                | 62.92                                                  |
| E.....    | 36.57                                                | 45.72                                                  |

of the two experiments. The differences between these pairs of mean values and also their percentage relations to the recall scores just prior to the interval are given in Table 4. It is these values in Table 4 that are measures of the amount of loss in recall.

In columns 1 and 3 of Table 5 are listed the mean numbers of trials required to learn the lists to the criterion adopted before the interval was inserted. In columns 2 and 4 are listed the corresponding numbers of trials required to relearn the list to the same criterion after the interval. The percentage relations of these relearning trials to the corresponding learning trials in columns 1 and 3 are given in Table 6. It is these relearning trials of Table 5 and the percentage values of Table 6 that constitute the last two measures of the amount of loss due to the interval.

Two facts should be pointed out that are significant for the validity of the conclusions concerning the relative effect of the two intervals. In both experiments the interval was inserted at approximately the same stage of learning (see columns 1 and 3, Table 3), and the two groups of subjects were practically equated in learning ability as indicated by the number of trials required to learn the lists to the same stage of mastery. (Compare learning values in column 1 and 3, Table 5.)

Inspection of these tabular results indicates there was a loss in retention for each of the conditions and for both intervals according to all four measures. The amount of loss increased with the length of the interval with but two exceptions in the twenty comparisons. Both exceptions are found in Condition A which represents the lowest stage of mastery

at which the interval was inserted. In this condition the two values are alike for number of words lost (Table 4), while slightly fewer mean trials were required to relearn for the three-day interval (Table 5). These two conclusions are in harmony with all of the experimental data on retention except the 'reminiscence' experiments.

The relation of the amount of loss to the stage of mastery at which the interval was inserted varied with the method of measurement. When measured in terms of number of words lost (Table 4) and in terms of relearning trials (Table 5), the amount of loss increased the later the stage of learning at which the interval was inserted. Condition D for the one-day interval (Table 4) is the single exception. The inverse relation was obtained when the loss was measured in percentage terms. According to these measures, the amount of loss tended to decrease as the interval was inserted later in the learning process. The only exceptions occurred in the case of one reversal in percentage of words recalled (Condition B, Table 4) and another in the trials to relearn after the three-day interval (Condition C, Table 6).

This seeming variation in results with the different measures of retention is explicable when one fact is noted. Comparisons of the *percentages* of loss for the various stages at which the interval was inserted are illegitimate because these percentages are necessarily computed on different base values, and thus are functions of two variables. For example, the base values for the percentages of words lost are the numbers of words recalled prior to the interval (Table 3), and these necessarily vary with the stage of insertion. These percentages of words lost are thus functions of the two variables, number of words lost and number of words learned prior to the interval. Likewise, the base for the percentages of trials lost is the number of learning trials required to attain the selected criterion (Table 5). Since these necessarily vary with the stage of learning at which the interval was inserted, the percentage values are thus a function of two variables. For purposes of comparison of amounts of loss in retention at the various stages of learning, the only valid measures are



number of words lost (Table 4 columns 1 and 2) and number of relearning trials (Table 5). Hence, we may conclude that the amount of loss increased the later the interval was inserted.

However, the previous comparisons of percentages of loss for the one and the three-day interval at corresponding stages of learning are valid because the percentages compared are computed from approximately the same base values. (Compare columns 3 and 4 in Table 5 and the 2 columns in Table 6.) When the base values are the same, comparisons in percentage terms give exactly the same results as measures of loss in terms of number of words or of relearning trials.

The wisdom of the common practice of measuring the amount of retention in terms of percentages of recall and percentages of trials saved (saving scores) may be questioned. Comparisons of such percentage values are valid only when they are derived from the same base values, and in that case the amount retained is directly measurable in terms of amount recalled or in number of trials saved. The translation of these direct measures of retention into percentage terms gives no new measure of retention. The percentages are sometimes more convenient for purposes of comparison, but we are prone to forget that such comparisons are valid only when the same base is employed.

*Retention in Relation to Efficacy of Learning.*—It should be made quite clear that the use of the phrase, ‘effect of a time interval upon learning and retention,’ throughout the paper has been merely for sake of verbal brevity, and no implication is intended as to the causal effect of time, *per se*. The phrase should be interpreted to mean the effects that occur during an interval of time between learning trials—whatever the causal factors may be. The purpose here is not to analyze these factors but to demonstrate that they operate upon learning and retention in like manner.

Again, it should be pointed out that the purpose of this study is not to determine which method of learning (distributed or massed practice) is most desirable in terms of delayed tests of retention, but rather to study retention as it is in-

volved in the learning process. Our hypothesis was that such factors that operate to influence retention during an interval between learning trials will determine the efficacy of that method of learning.

### CONCLUSIONS

When the effects of a time interval were measured by both learning and retention scores obtained from a single experimental situation, the results justify the following conclusions:

1. The introduction of the time interval exerted a detrimental effect upon both learning and retention.
2. The detrimental effect upon both learning and retention increased with the length of the time interval.
3. The degree of the detrimental effect of the time interval upon both learning and retention varied directly with the stage of learning at which it was introduced: the greater the loss in retention during the interval the greater the detrimental effect upon learning.

Our experimental results thus substantiate our hypothesis that the interval exerts the same effect upon both processes under the same experimental conditions. In the light of these data, it is unnecessary to make the paradoxical assumption that loss in retention is an aid to learning.

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### REFERENCES

1. AUSTIN, S. M., A study in logical memory, *Amer. J. Psychol.*, 1921, 32, 370-403.
2. BALLARD, P. B., Obliviscence and reminiscence, *Brit. J. Psychol. Monog. Suppl.*, 1913 (No. 2), 1, pp. 82.
3. BROWN, W., To what extent is memory measured by a single recall?, *J. Exper. Psychol.*, 1923, 6, 377-382.
4. CARR, H. A., Distribution of effort, *Psychol. Bull.*, 1919, 16, 26-28.
5. CLARK, B. E., The effect upon retention of varying lengths of study periods and rest intervals in distributed learning time, *J. Educ. Psychol.*, 1928, 19, 552-559.
6. CUMMINS, R. A., Improvement and the distribution of practice, *Teach. Coll. Contrib. Educ.*, 1919, No. 97, pp. 72.
7. GORDON, K., Class results with spaced and unspaced memorizing, *J. Exper. Psychol.*, 1925, 8, 337-343.
8. HARDY, M. C., The effect of distribution of practice in learning a stylus maze, *J. Comp. Psychol.*, 1930, 10, 85-96.
9. HUGUENIN, C., Reviviscence paradoxale, *Arch. de Psychol.*, 1914, 14, 379-383.

10. LASHLEY, K. S., The acquisition of skill in archery, *Papers from Dept. of Mar. Biol. of Carnegie Inst. of Washington*, 1915, 7, 105-128.
11. LYON, D. O., The relation of length of material to time taken for learning and the optimum distribution of time, *J. Educ. Psychol.*, 1914, 5, 1-9, 85-91, 155-163.
12. McCLATCHY, V. R., The optimal position of a rest period in learning, *J. Exper. Psychol.*, 1925, 8, 251-277.
13. McGECH, G. O., The age factor in reminiscence: a comparative study of pre-school children and college students, *J. Genet. Psychol.*, 1935, 47, 98-120.
14. —, The conditions of reminiscence, *Amer. J. Psychol.*, 1935, 47, 65-89.
15. MURPHY, H. H., Distribution of practice periods in learning, *J. Educ. Psychol.*, 1916, 7, 150-162.
16. NICHOLAI, F., Experimentelle Untersuchungen über das Haften von Gesichtseindrücken und dessen zeitlichen Verlauf, *Arch. f. d. ges. Psychol.*, 1922, 42, 132-149.
17. PERKINS, N. L., The value of distributed repetitions in rote learning, *Brit. J. Psychol.*, 1914, 7, 253-261.
18. RANSON, D. AND SKAGGS, E. B., Distribution of effort in a perceptual-motor task. Series II, *J. Exper. Psychol.*, 1936, 19, 776-782.
19. RENSHAW, S. AND SCHWARZBEK, W. C., The dependence of the form of the pursuit-meter learning function on the length of the inter-practice rests, *J. Genet. Psychol.*, 1938, 18, 3-29.
20. ROBINSON, E. S., The relative efficiencies of distributed and concentrated study in memorizing, *J. Exper. Psychol.*, 1921, 4, 327-343.
21. SKAGGS, E. B., Distribution of effort in a perceptual-motor task, *J. Exper. Psychol.*, 1935, 18, 797-801.
22. TROW, W. C., Recall vs. repetition in the learning of rote and meaningful material, *Amer. J. Psychol.*, 1928, 40, 112-116.
23. TSAI, L. S., The relation of retention to the distribution of relearning, *J. Exper. Psychol.*, 1927, 10, 30-39.
24. WARDEN, C. J., The distribution of practice in animal learning, *Comp. Psychol. Monog.*, 1923, 1, No. 3, pp. 64.
25. WILLIAMS, O., A study of the phenomena of reminiscence, *J. Exper. Psychol.*, 1926, 9, 368-87.







